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APPLICATION FOR LETTERS PATENT

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**A SYSTEM FOR LOCATING AN INDIVIDUAL IN A
FACILITY**

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TECHNICAL FIELD

The invention relates to personnel locating systems, travel reservation systems, airport security systems, radio frequency identification devices.

BACKGROUND OF THE INVENTION

Travel reservation and baggage tracking systems are known in the art. Passengers typically purchase tickets in advance of travel, and are included in a database of a reservation system as having a reservation. On the date of travel, they must check in, or their seat will be given up to other passengers. Because statistics show that there will always be a number of passengers who will not show up on the designated date of travel, carriers typically "overbook" by selling a number of seats over the number of seats that are actually available, based on mathematical calculations. If the passenger does not check in, their seat may be used to accomodate overbooking, or may be given to standby passengers. The following U.S. patents relate to reservation systems and are incorporated herein by reference: 5,401,944; 5,151,692; 5,051,565; 5,010,240; 4,984,156; 4,931,932; 4,449,186; 4,247,795; 3,750,103.

When a passenger enters a travel depot (e.g., an airport), they must therefore check in to make sure the carrier (e.g., airline) knows they are present and to make sure that their seat is not given away to someone else. This typically involves standing in line and waiting for an employee to verify that the correct traveler is bearing a ticket. The employee receives the ticket and, using

1 a reservation system, issues a boarding pass, with a seat assignment, indicating
2 to the system that the seat is no longer available to be given away.

3 Traditionally, check in occurred simultaneously with a baggage check-in,
4 with an employee marking the traveler's luggage with a tag indicting the
5 destination where the bag is to be sent, printing a baggage receipt for the
6 customer, and logging the bag in the reservation and baggage handling system.

7 Business travelers, however, typically do not have any bags to check and
8 prefer not to wait in line. Also, many airports offer curbside check-in, which
9 allows a passenger to check in bags at the curb before entering the airport, where
10 lines are shorter because a gratuity is expected. The business travelers and
11 travelers who have used the curbside check in typically go directly to the podium
12 adjacent the departure gate and check in there. While the line at the podium may
13 be shorter, it is still a line.

14 There are many reasons why it would be useful to determine the presence
15 of an individual in an airport or other travel depot. If a flight is about to leave,
16 airline staff may desire to make an attempt to determine if a checked in passenger
17 is in the airport. It is also frequently desirable to locate airline staff, such as
18 pilots, flight attendants, wheelchair attendants, mechanics etc., or airport staff, such
19 as security, or merchants or other persons who work in airports, for a variety of
20 reasons. This is presently attempted through paging, which is sometimes difficult
21 to hear, and is often annoying or competing with more important messages, such
22 as gate change announcements, or information about which rows are boarding.

1 It is also useful to determine the location of a passenger in evaluating
2 terrorist threats. A terrorist who has planted a bomb in his or her luggage is
3 likely to leave the premises and not board the flight for which the luggage was
4 checked.

5 Passengers in airports typically need gate and flight information in a hurry.
6 Such information may be obtained from airline staff, but this typically involves
7 standing in long lines. This information is therefore more typically gathered by
8 reading a monitor which lists flight numbers, destinations, gates, and status. A
9 problem is that in some airports, each airline has their own monitors, so a traveler
10 may have to walk a great distance to try to find a monitor for a particular airline.
11 Monitors also contain vast amounts of information, most of it of no interest to
12 a particular traveler. This makes it difficult to find useful information in a hurry.

13 Switching antennas connected to an interrogator is disclosed in commonly
14 assigned U.S. Patent Application Serial No. 08/772,173, filed December 18, 1996,
15 titled "Communication System Including Diversity Antenna Queuing," and listing
16 Clifton W. Wood, Jr. as inventor. Antenna switching for this application is
17 performed for diversity purposes.

18 19 20 SUMMARY OF THE INVENTION

21 The invention provides a system for locating an individual in a facility.
22 The system comprises a portable wireless transponder device borne by the
23 individual; an interrogator; and a plurality of antennas distributed in the facility.

1 The antennas are selectively separately connected to the interrogator. The
2 interrogator, when connected to any of the antennas has a communications range
3 covering less than the area of the entire facility. The interrogator repeatedly
4 transmits a wireless command to the portable wireless transponder device using
5 alternating antennas. The portable wireless transponder device transmits data
6 identifying the portable wireless transponder device in response to a command if
7 the portable wireless transponder device is within communications range of the
8 antenna sending the command. Thus, the individual is located by determining
9 with which antenna the interrogator was able to establish communications with the
10 portable wireless transponder device.

11 12 **BRIEF DESCRIPTION OF THE DRAWINGS**

13 Preferred embodiments of the invention are described below with reference
14 to the following accompanying drawings.

15 Fig. 1 is a plan view of a travel depot facility, such as an airport,
16 including a system, embodying the invention, for locating an individual.

17 Fig. 2 is a block diagram of the system of Fig. 1, further including an
18 interface with an airline reservation and baggage tracking system, and further
19 including monitors for displaying information of particular interest to passengers
20 in the area of the monitor.

21 Fig. 3 is a perspective view showing a monitor included in the system of
22 Fig. 2.

23 Fig. 4 is a front view of a card used in the system of Figs. 1 or 2.

1 Fig. 5 is a circuit schematic of an interrogator included in the system of
2 Figs. 1 or 2.

3 Fig. 6 is a circuit schematic of circuitry included in card of Fig. 4.

4 Fig. 7 is a block diagram of an interrogator included in the system of Figs.
5 1 or 2.

6 Fig. 8 is a circuit schematic of DPSK circuitry included in the interrogator
7 of Fig. 7.

8 Fig. 9 is a circuit schematic of RF circuitry included in the interrogator of
9 Fig. 7.

10 Fig. 10 is a plan view of a card in accordance with an alternative
11 embodiment of the invention.

12 Fig. 11 is a block diagram illustrating assembly of the card of Fig. 10.

13 Fig. 12 is a flow chart illustrating a routine run by the system of Figs. 1
14 or 2 to log locations of individuals.

15 Fig. 13 is a flow chart illustrating a routine run by the system of Figs. 1
16 or 2, used in connection with the routine of Fig. 12, to determine the location of
17 an individual.

18 Fig. 14 is a flow chart illustrating a routine run by the system of Fig. 2
19 to check in a passenger using the card of Figs. 4 or 10 as an electronic boarding
20 pass.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

Fig. 1 shows a travel depot facility 10, such as an airport, including a system 12 (see Fig. 2) for locating an individual. The facility 10 includes various areas of a typical facility such as a main terminal area 14 which typically includes a baggage check in area 16, shops, restaurants, etc. The facility 10 further includes a terminal concourse area 18 which one enters after passing a security check point 20. The terminal concourse area 18 includes multiple gate doors 22 defining controlled access points. More particularly, the gate doors 22 are typically locked until a flight is available for departure or is being deplaned. Airline staff control passage through the gate doors and only permit people with boarding passes through the gate doors 22. The gate doors 22 lead to jetways 24 which are movable to define a path into an airplane. The terminal area 18 typically includes podiums 28 where airline personnel are located. The terminal area 18 also includes multiple seating areas 30 which may be grouped off by gate.

The system 12 (see Fig. 2) includes portable wireless transponder devices 32 borne by passengers, airport employees, contractors, airline and contractor employees, etc. In the illustrated embodiment, the devices 32 include circuitry such as the circuitry described in detail in commonly assigned U.S. Patent Application Serial No. 08/705,043, filed August 29, 1996 and incorporated herein

1 by reference. In one embodiment, the portable transponder devices 32 have card
2 shaped housings with length and width dimensions corresponding to standard
3 length and width dimensions of credit cards. In one embodiment, the transponder
4 devices 32 include photographs of the respective individuals associated with the
5 devices. The transponder devices 32 are, more particularly, intelligent radio
6 frequency identification devices or remote intelligent communications (RIC) devices
7 which communicate at microwave frequencies.

8 Fig. 4 shows but one example of a housing for a device 32, in the
9 form of an employee identification badge or card including an intelligent radio
10 frequency identification device integrated circuit 34. The integrated circuit 34
11 includes a transmitter, a receiver, a microprocessor, and a memory. The
12 housing for the device 32 shown in Fig. 4 includes a card 36 made of plastic
13 or other suitable material. In one embodiment, the integrated circuit 34 is
14 laminated to the back face of the card 36, and the card forms a visible
15 portion of the badge. In another embodiment, the integrated circuit 34 is
16 bonded to the back face of the card by embedding it within a thin bond line
17 of epoxy-based material. Alternatively, the integrated circuit 34 is embedded
18 into the plastic card 36. In one embodiment, the front face of the badge has
19 visual identification features including a photograph 38 of the bearer as well
20 as identifying text. The device 32 further includes a send/receive antenna 40
21 coupled to the integrated circuit 34, and a battery 42 coupled to the integrated
22 circuit 34 to supply power to the integrated circuit. The battery 42 and antenna
23 40 are embedded or supported inside the plastic card 36.

1 The battery 42 can take any suitable form. Preferably, the battery type
2 will be selected depending on weight, size, and life requirements for a particular
3 application. In one embodiment, the battery 42 is a thin profile button-type cell
4 forming a small, thin energy cell more commonly utilized in watches and small
5 electronic devices requiring a thin profile. A button-type cell has a pair of
6 electrodes, an anode formed by one face and a cathode formed by an opposite
7 face. Exemplary button-type cells are disclosed in several pending U.S. patent
8 applications including U.S. Patent Application Serial No. 08/205,957, "Button-Type
9 Battery Having Bendable Construction and Angled Button-Type Battery," listing
10 Mark E. Tuttle and Peter M. Blonsky as inventors; U.S. Patent Application Serial
11 No. 08/321,251, "Button-Type Batteries and Method of Forming Button-Type
12 Batteries," listing Mark E. Tuttle as inventor; and U.S. Patent Application Serial
13 No. 08/348,543, "Method of Forming Button-Type Batteries and a Button-Type
14 Battery Insulating and Sealing Gasket," listing Mark E. Tuttle as inventor. These
15 patent applications and resulting patents are hereby incorporated by reference. In
16 an alternative embodiment, the battery 42 comprises a series connected pair of
17 button type cells. Alternative power supplies can be used instead of batteries,
18 in alternative embodiments.

19 Fig. 5 illustrates but one alternative housing supporting the circuit 34.
20 More particularly, Fig. 5 illustrates a miniature housing 42 encasing the circuit 34
21 to define a tag which can be supported by a person or object. The housing 42
22 preferably has the general shape and size, in plan view, of a postage stamp. The
23 embodiment of Fig. 5 also houses a card 44 supporting the circuit 34 in the

1 housing 42. The card 44 is formed of plastic or other suitable material having
2 a thickness of about 0.040 inches, a width of about 1.25 inches, and a height of
3 about 1.25 inches. In one embodiment, the circuit 34 is bonded to a back face
4 of the card 44 with a thin layer of non-conductive epoxy material that cooperates
5 with the card to define the housing 42. The circuit 34 is coupled to a send
6 antenna 48, and a receive antenna 46, and receives power from a battery 42
7 which can be similar to the battery included in the embodiment of Fig. 4. The
8 battery 42, and antennas 46 and 48 are supported in the housing 42 by the
9 card 44.

10 Although two particular types of housings have been disclosed, the circuit
11 34 can be included in any appropriate housing. The circuit 34 is of a small size
12 that lends itself to applications employing small housings, such as cards, miniature
13 tags, etc. Larger housings can also be employed. The circuit 34, housed in any
14 appropriate housing, can be supported from a person, or attached to a object (or
15 a peoples possessions) in any desired manner; for example using double sided
16 tape, glue, lanyards, leash, nails, staples, rivets, or any other fastener. The
17 housing can be sewn on to an object, hung from an object, implanted in an object
18 (hidden), etc.

19 Various configurations are possible for the antenna connected to the circuit
20 34. In one embodiment, separate antennas 46 and 48 are provided for receiving
21 and sending (Fig. 5). In another embodiment, a single antenna 40 is shared by
22 the receiver and transmitter (Fig. 4). In one embodiment, one or more antennas
23 are defined by conductive epoxy screened onto a card or housing. In the

illustrated embodiment, the antenna is conductively bonded to the integrated circuit 34 via bonding pads.

The system 12 further includes an interrogator 50. The card 36 transmits and receives radio frequency communications to and from the interrogator 50. The system 12 further includes an array of antennas 52 (or send/receive antenna pairs) alternately coupled to the interrogator 50. The interrogator 50 includes transmitting and receiving circuitry, similar to that implemented in the circuit 34. In one embodiment, the system 12 further includes a controller 54. In the illustrated embodiment, the controller 54 is a computer. The controller 54 acts as a master in a master-slave relationship with the interrogator 50. The controller 54 includes an applications program for controlling the interrogator 50 and interpreting responses, and a library of radio frequency identification device applications or functions. Most of the functions communicate with the interrogator 50. These functions effect radio frequency communication between the interrogator 50 and the card 32. In one embodiment, the controller 54 and the interrogator 50 are combined together (e.g., in a common housing), or functions of the host computer are implemented in hard wired digital logic circuitry.

In the illustrated embodiment, the communications system 10 includes multiple selectable transmit antennas X1, X2, X3 etc., and multiple receive antennas R1, R2, R3 etc. connected to the interrogator 50. Each antenna pair X1, R1, X2, R2, etc. defines an antenna 52 of the antenna array for purposes of the discussion below. In one embodiment, the communications system 10 includes combined antennas that are used both for transmitting and receiving by the

1 interrogator 50. Generally, the interrogator 50 transmits an interrogation signal
2 or command, such as an "Identify" command, ("forward link") via one of the
3 antennas 52. The card 32 receives the incoming interrogation signal via its
4 antenna, if it is within receiving range of the particular antenna 52 used to
5 transmit. Upon receiving the signal, the card 32 responds by generating and
6 transmitting a responsive signal or reply ("return link"). The interrogator 50 is
7 described in greater detail below.

8 In the illustrated embodiment, the responsive signal is encoded with
9 information that uniquely identifies, or labels the particular card 32 that is
10 transmitting, so as to identify any object or person with which the card 32 is
11 associated.

12 In the embodiment illustrated in Fig. 2, multiple cards 32 are employed;
13 however, there is no communication between the cards 32. Instead, the multiple
14 cards 32 communicate with the interrogator 50. Multiple cards 32 can be used
15 in the same range of an antenna 52.

16 Various U.S. patent applications, which are incorporated herein by reference,
17 disclose features that are employed in various alternative embodiments of the
18 invention: 08/092,147, filed July 15, 1993, "Wake Up Device for a
19 Communications System" and continuation application 08/424,827, filed April 19,
20 1995, "Wake Up Device for a Communications System"; 08/281,384, filed July
21 27, 1994, "Communication System Having Transmitter Frequency Control";
22 07/990,918, filed December 15, 1992, now U.S. Patent No. 5,365,551, "Data
23 Communication Transceiver Using Identification Protocol"; 07/899,777, filed June

1 17, 1992, "Radio Frequency Identification Device (RFID) and Method of
2 Manufacture, Including an Electrical Operating System and Method," now
3 abandoned; 07/921,037, filed July 24, 1992, "Anti-Theft Method for Detecting The
4 Unauthorized Opening of Containers and Baggage," now abandoned; 07/928,899,
5 filed August 12, 1992, "Electrically Powered Postage Stamp or Mailing or
6 Shipping Label Operative with Radio Frequency (RF) Communications," now
7 abandoned; and 08/032,384, filed on March 17, 1993, "Modulated Spread Spectrum
8 in RF Identification Systems Method," now allowed.

9 The integrated circuit 34 is advantageous over prior art devices that utilize
10 magnetic field effect systems because, with the circuit 34, a greater range can be
11 achieved, and more information can be obtained (instead of just an identification
12 number). As a result, the circuit 34 can be used for the application of the
13 present invention, where transmission over a large range is required. In one
14 embodiment, the sensitivity of the cards 32 is adjustable so that only devices
15 within an adjustable range of an antenna 52 will respond. In another embodiment,
16 the power of the interrogator 50 is adjustable so that only devices within a certain
17 range of an antenna 52 will respond.

18 A power conservation problem is posed by such implementations where
19 batteries are used to supply power to the integrated circuits 34. If the integrated
20 circuit 34 operates continuously at full power, battery life will be short, and card
21 32 will have to be frequently replaced. If the battery 42 is permanently sealed
22 in a housing, replacement of the battery will be difficult or impossible. For
23 example, one reason for sealing the battery with the integrated circuit 34 and

1 antenna(s) in a housing is to simplify the design and construction, to reduce the
2 cost of production, and protect the electrical interconnections between devices.
3 Another reason is protection of the battery and integrated circuit 34 from moisture
4 and contaminants. A third reason is to enhance the cosmetic appeal of the card
5 32 by eliminating the need for an access port or door otherwise necessary to
6 insert and remove the battery. When the battery is discharged, the entire badge
7 or stamp is then discarded. It is therefore desirable to incorporate power
8 conservation techniques into the integrated circuit 32 in order to extend useful life.

9 Fig. 6 is a circuit schematic of the integrated circuit 34 utilized in the
10 devices of Figs. 4 or 5. In the embodiment shown in Fig. 6, the circuit 34 is
11 a monolithic integrated circuit. In the illustrated embodiment, the integrated
12 circuit 34 comprises a single die, having a size of 209 x 116 mils². The
13 integrated circuit 34 includes a receiver 56, a transmitter 58, a micro controller
14 or microprocessor 60, a wake up timer and logic circuit 62, a clock recovery and
15 data recovery circuit 64, and a bias voltage and current generator 66.

16 In one embodiment, the circuit 34 switches between a "sleep" mode of
17 operation, and higher power modes to conserve energy and extend battery life
18 during periods of time where no interrogation signal is received by the circuit 34.
19 The wake up timer and logic circuitry 62 provides this switching.

20 In one embodiment, a spread spectrum processing circuit 68 is also
21 included in the circuit 34. In this embodiment, signals transmitted and received
22 by the interrogator 50, and signals transmitted and received by the circuit 34 are
23 modulated spread spectrum signals. Spread spectrum modulation is described

below. In one illustrated embodiment, the modulation scheme for replies sent by the transmitter 58 is selectable. One of the available selections for replies sent by the transmitter 58 is modulated spread spectrum.

Spread Spectrum Modulation

Many modulation techniques minimize required transmission bandwidth. However, the spread spectrum modulation technique employed in the illustrated embodiment requires a transmission bandwidth that is up to several orders of magnitude greater than the minimum required signal bandwidth. Although spread spectrum modulation techniques are bandwidth inefficient in single user applications, they are advantageous where there are multiple users, as is the case with the instant circuit 34. The spread spectrum modulation technique of the illustrated embodiment is advantageous because the interrogator signal can be distinguished from other signals (e.g., radar, microwave ovens, etc.) operating at the same frequency. The spread spectrum signals transmitted by the circuit 34 and by the interrogator 50 are pseudo random and have noise-like properties when compared with the digital command or reply. The spreading waveform is controlled by a pseudo-noise or pseudo random number (PN) sequence or code. The PN code is a binary sequence that appears random but can be reproduced in a predetermined manner by the circuit 34. More particularly, incoming spread spectrum signals are demodulated by the circuit 34 or by the interrogator 50 through cross correlation with a version of the pseudo random carrier that is generated by the circuit 34 itself or the interrogator 50 itself, respectfully. Cross

1 correlation with the correct PN sequence unspreads the spread spectrum signal and
2 restores the modulated message in the same narrow band as the original data.

3 A pseudo-noise or pseudo random sequence (PN sequence) is a binary
4 sequence with an autocorrelation that resembles, over a period, the autocorrelation
5 of a random binary sequence. The autocorrelation of a pseudo-noise sequence
6 also roughly resembles the autocorrelation of band-limited white noise. A pseudo-
7 noise sequence has many characteristics that are similar to those of random binary
8 sequences. For example, a pseudo-noise sequence has a nearly equal number of
9 zeros and ones, very low correlation between shifted versions of the sequence, and
10 very low cross correlation between any two sequences. A pseudo-noise sequence
11 is usually generated using sequential logic circuits. For example, a pseudo-noise
12 sequence can be generated using a feedback shift register.

13 A feedback shift register comprises consecutive stages of two state memory
14 devices, and feedback logic. Binary sequences are shifted through the shift
15 registers in response to clock pulses, and the output of the various stages are
16 logically combined and fed back as the input to the first stage. The initial
17 contents of the memory stages and the feedback logic circuit determine the
18 successive contents of the memory.

19 The illustrated embodiment employs direct sequence spread spectrum
20 modulation. A direct sequence spread spectrum (DSSS) system spreads the
21 baseband data by directly multiplying the baseband data pulses with a
22 pseudo-noise sequence that is produced by a pseudo-noise generator. A single
23 pulse or symbol of the PN waveform is called a "chip." Synchronized data

1 symbols, which may be information bits or binary channel code symbols, are
2 added in modulo-2 fashion to the chips before being modulated. The receiver
3 performs demodulation. For example, in one embodiment the data is phase
4 modulated, and the receiver performs coherent or differentially coherent phase-shift
5 keying (PSK) demodulation. In another embodiment, the data is amplitude
6 modulated. Assuming that code synchronization has been achieved at the receiver,
7 the received signal passes through a wideband filter and is multiplied by a local
8 replica of the PN code sequence. This multiplication yields the unspread signal.

9 A pseudo-noise sequence is usually an odd number of chips long. In the
10 illustrated embodiment, one bit of data is represented by a thirty-one chip
11 sequence. A zero bit of data is represented by inverting the pseudo-noise
12 sequence.

13 Spread spectrum techniques are also disclosed in the following patent
14 applications and patent, which are incorporated herein by reference: U.S. Patent
15 Application Serial No. 08/092,147; U.S. Patent Application Serial No. 08/424,827,
16 filed April 19, 1995; and U.S. Patent No. 5,121,407 to Partyka et al. They are
17 also disclosed, for example, in "Spread Spectrum Systems," by R.C. Dixon,
18 published by John Wiley and Sons, Inc.

19 20 Backscatter and Frequency Hopping

21 The interrogator 50 sends out a command that is spread around a certain
22 center frequency (e.g, 2.44 GHz). After the interrogator transmits the command,
23 and is expecting a response, the interrogator switches to a CW mode (continuous

1 wave mode). In the continuous wave mode, the interrogator does not transmit any
2 information. Instead, the interrogator just transmits 2.44 GHz radiation. In other
3 words, the signal transmitted by the interrogator is not modulated. After the
4 circuit 34 receives the command from the interrogator, the circuit 34 processes the
5 command. If the circuit 34 is in a backscatter mode it alternately reflects or does
6 not reflect the signal from the interrogator to send its reply. For example, in the
7 illustrated embodiment, two halves of a dipole antenna are either shorted together
8 or isolated from each other to send a reply.

9 Frequency hopping is employed in one embodiment. In the illustrated
10 embodiment, frequency hopping does not occur when the interrogator transmits a
11 command, but occurs when the interrogator is in the continuous wave mode. The
12 interrogator, in the continuous wave mode, hops between various frequencies close
13 to the 2.44 GHz frequency. These various frequencies are sufficiently close to
14 the 2.44 GHz frequency that backscatter antenna reflection characteristics of the
15 circuit 34 are not appreciably altered. Because the interrogator is hopping
16 between frequencies, the interrogator knows what frequency backscatter reflections
17 to expect back from the circuit 34. By hopping between various frequencies, the
18 amount of time the interrogator continuously uses a single frequency is reduced.
19 This is advantageous in view of FCC regulatory requirements.

20 In one illustrated embodiment, no attempt is made to frequency hop at the
21 interrogator to a pseudo-random sequence and then correlate to that at the
22 receiver. However, in alternative embodiments, such correlation takes place.
23

1 In one embodiment, the transmitter 58 is switchable between operating in
2 a modulated backscatter transmitter mode, and operating in an active mode. The
3 transmitter 58 switches between the backscatter mode and the active mode in
4 response to a radio frequency command, instructing the transmitter to switch, sent
5 by the interrogator 50 and received by the receiver 56. In the active mode, a
6 carrier for the transmitter 58 is extracted from a signal received by the
7 receiver 56.

8 Active transmitters are known in the art. See, for example, U.S. Patent
9 Application Serial No. 08/281,384. U.S. Patent Application Serial No. 08/281,384
10 also discloses how transmit frequency for the transmitter 58 is recovered from a
11 message received via radio frequency from the interrogator 50.

12 In one embodiment, the transmitter 58 is capable of transmitting using
13 different modulation schemes, and the modulation scheme is selectable by the
14 interrogator. More particularly, if it is desired to change the modulation scheme,
15 the interrogator sends an appropriate command via radio frequency. In this
16 embodiment, the transmitter can switch between multiple available modulation
17 schemes such as Binary Phase Shift Keying (BPSK), Direct Sequence Spread
18 Spectrum, On-Off Keying (OOK), and Modulated Backscatter (MBS).

19 In one embodiment, the clock for the entire integrated circuit 16 is
20 extracted from the incoming message itself by clock recovery and data recovery
21 circuitry 64. This clock is recovered from the incoming message, and used for
22 timing for the micro controller 60 and all the other clock circuitry on the chip,
23

1 and also for deriving the transmitter carrier or the subcarrier, depending on
2 whether the transmitter is operating in active mode or backscatter mode.

3 In addition to recovering a clock, the clock recovery and data recovery
4 circuit 64 also performs data recovery on valid incoming signals. The valid
5 spread spectrum incoming signal is passed through the spread spectrum processing
6 circuit 68, and the spread spectrum processing circuit 68 extracts the actual ones
7 and zeros of data from the incoming signal. More particularly, the spread
8 spectrum processing circuit 68 takes the chips from the spread spectrum signal,
9 and reduces each thirty-one chip section down to a bit of one or zero, which is
10 passed to the micro controller 60.

11 The micro controller 60 includes a serial processor, or I/O facility that
12 received the bits from the spread spectrum processing circuit 68. The micro
13 controller 60 performs further error correction. More particularly, a modified
14 hamming code is employed, where each eight bits of data is accompanied by five
15 check bits used by the micro controller 60 for error correction. The micro
16 controller 60 further includes a memory, and after performing the data correction,
17 the micro controller 60 stores bytes of the data bits in memory. These bytes
18 contain a command sent by the interrogator 50. The micro controller 60 responds
19 to the command.

20 For example, the interrogator 50 may send a command over one of the
21 antennas 52 requesting that any integrated circuit 34 in communications range of
22 that antenna 52 respond with the integrated circuit's identification number. Status
23

1 information is also returned to the interrogator 50 from the integrated circuit 34
2 when the circuit 34 responds.

3 The transmitted replies have a format similar to the format of incoming
4 messages. More particularly, a reply starts with a preamble (e.g., all zeros in
5 active mode, or alternating double zeros and double ones in backscatter mode),
6 followed by a Barker or start code which is thirteen bits long, followed by actual
7 data.

8 No stop bits are included in the incoming message or reply, in the
9 preferred embodiment. Instead, part of the incoming message describes how many
10 bytes are included, so the integrated circuit 34 knows how much information is
11 included. Similarly, part of the outgoing reply describes how many bytes are
12 included, so the interrogator 50 knows how much information is included. The
13 incoming message and outgoing reply preferably also include a check sum or
14 redundancy code so that the integrated circuit 34 or the interrogator 50 can
15 confirm receipt of the entire message or reply.

16 After the reply is sent, the integrated circuit 34 returns to the sleep mode,
17 and the wake up timer and logic circuit 62 starts timing again for the next wake
18 up (e.g., in 16 milliseconds, or whatever period is selected).

19 The interrogator 50 provides a communication link between the controller
20 54 and the integrated circuit 34. In one embodiment, the interrogator 50 connects
21 to the controller 54 via an IEEE-1284 enhanced parallel port (EPP). The
22 interrogator communicates with the circuit 34 via a selected RF (microwave)
23 antenna 52.

1 In one embodiment, communications from the interrogator 50 to the circuit
2 34, and communications from the circuit 34 to the interrogator 50 use different
3 physical protocols.

4 The physical communications protocol for communications from the
5 interrogator 50 to the circuit 34 is referred to as the "forward link" protocol. The
6 forward link data is sent in the following order:

7 Preamble

8 Barker Code

9 Command Packet

10 Check Sum

11 A Maximal Length Pseudo Noise (PN) Sequence is used in the Direct
12 Sequence Spread Spectrum (DSSS) communications scheme in the forward link.

13 In one embodiment, the sequence is generated by a linear feedback shift register
14 of the form [5,2]. That is, there are five registers, the output of the second
15 register is X-ORed with the output of the fifth register, and the result is fed into
16 the input of the first register one. This produces a repeating 31 "chip" sequence.

17 The sequence ends with all registers set to one. The sequence is taken from the
18 output of the first register. This code is synchronous with the data in that each
19 data bit comprises one and only one full PN sequence. The chip sequence for
20 each bit is:

21 001 1010 0100 0010 1011 1011 0001 1111.

22 Other embodiments are, of course, possible. For example, other forms of
23 linear feedback shift registers can be employed.

1 In one embodiment, a zero bit is transmitted as one inverted full cycle of
2 the PN sequence. A one bit is transmitted as one full non-inverted cycle of the
3 PN sequence.

4 In the illustrated embodiment, the data is not differentially encoded.

5 In one embodiment, there are at least two available "chipping" rates. One
6 rate is 9.5375 Mchips/sec (high band) and another rate is 4.768750 Mchips/sec
7 (low band).

8 The preamble precedes the data. In one embodiment, the preamble includes
9 a series of zeros, followed by a start or Barker code. In embodiments where the
10 transponder 16 includes wake up timer and logic circuitry 36, the preamble
11 includes a series of zeros for a duration equal to the wakeup interval (e.g., .5, 16,
12 64, or 256 ms) plus 2 milliseconds, followed by a start or Barker code.

13 In one embodiment, the Barker code is defined by the following bit string:
14 1111 1001 1010 1. Other embodiments are possible.

15 Command data is grouped into 13-bit words. Each word includes
16 eight data bits (D7, D6, D5, D4, D3, D2, D1, D0) and five ECC (Error
17 Correction Code) bits (P4, P3, P2, P1, and P0). In one embodiment, the bit
18 transmission order is (with D7 transmitted first):

19 D7, D6, D5, D4, D3, D2, D1, D0, P4, P3, P2, P1, P0 ...

20 In one embodiment, the ECC bits (P4-P0) are generated using the
21 following equations:

22
$$P0 = (D1 + D2 + D5 + D7) \text{ modulo } 2$$

23
$$P1 = [(D1 + D3 + D4 + D6) \text{ modulo } 2] \text{ Complement}$$

1 P2 = (D0 + D2 + D3 + D6 + D7) modulo 2

2 P3 = [(D0 + D4 + D5 + D6 + D7) modulo 2] Complement

3 P4 = (D0 + D1 + D2 + D3 + D4 + D5) modulo 2.

4 Data rates depend on which data band is being used. A high data band
5 has an effective data rate (adjusting for PN and ECC) of 189.3 Kbps. A low
6 data band has an effective data rate of 94.68 Kbps.

7 In the illustrated embodiment, a 16-bit check sum is provided to detect bit
8 errors on the packet level. A circuit 34 can be programmed to either return a
9 reply if a bad check sum is found in the forward link, or to simply halt execution
10 and send no replies. In one embodiment, a 16 bit CRC is employed in the
11 forward link, the return link, or both, instead of or in addition to the check sum.

12 The physical communications protocol for communications from the circuit
13 34 to the interrogator 50 is referred to as the "return link" protocol. In the
14 illustrated embodiment, the return link messages are sent in the following order:

15 Preamble,

16 Barker Code,

17 Reply Packet

18 Check Sum

19 After sending a command, the interrogator sends a continuous unmodulated
20 RF signal with a frequency of 2.44175; Ghz. Return link data is Differential
21 Phase Shift Key (DPSK) modulated onto a square wave subcarrier with a
22 frequency of 596.1 Khz. A data 0 corresponds to one phase and data 1
23 corresponds to another, shifted 180 degrees from the first phase. The subcarrier

1 is used to modulate antenna impedance of a card 32. For a simple dipole, a
2 switch between the two halves of the dipole antenna is opened and closed. When
3 the switch is closed, the antenna becomes the electrical equivalent of a single
4 half-wavelength antenna that reflects a portion of the power being transmitted by
5 the interrogator. When the switch is open, the antenna becomes the electrical
6 equivalent of two quarter-wavelength antennas that reflect very little of the power
7 transmitted by the interrogator. The switch driving a printed half wavelength
8 dipole antenna gives a typical range of 15 feet when the interrogator 50 transmits
9 at 30 dBm into a 6 dB gain antenna. Therefore, antennas 52 are located no more
10 than 15 feet apart in areas of the facility 10 where it is desirable to locate people
11 or objects.

12 The preamble for the return link includes 2000 bits, alternating 2 zeros then
13 2 ones, etc., and a 13-bit start (Barker) code. Alternative preambles are possible.

14 In the illustrated embodiment, the start code or Barker Code is defined by
15 the following bit string: 1111 1001 1010 1.

16 The reply link data is grouped in 13 bit words. Each word is composed
17 of 8 data bits (D7, D6, D5, D4, D3, D2, D1, D0) and 5 ECC bits (P4, P3, P2,
18 P1, P0).

19 The Block Encoded Sequence is D7, D6, D5, D4, D3, D2, D1, D0, P4,
20 P3, P2, P1, P0.

21 The Block ECC Bits (P4-P0) are generated using the following equations:

22
$$P0 = (D1 + D2 + D5 + D7) \text{ modulo } 2$$

23
$$P1 = [(D1 + D3 + D4 + D6) \text{ modulo } 2] \text{ Complement}$$

1 $P2 = (D0 + D2 + D3 + D6 + D7) \text{ modulo } 2$

2 $P3 = [(D0 + D4 + D5 + D6 + D7) \text{ modulo } 2] \text{ Complement}$

3 $P4 = (D0 + D1 + D2 + D3 + D4 + D5) \text{ modulo } 2.$

4 In the illustrated embodiment, the bit duration is $6.71 \mu s$ making the
5 effective data rate 91.75 Kbps for the return link.

6 In the illustrated embodiment, a 16-bit check sum is provided to detect bit
7 errors on the packet level. In one embodiment, a 16 bit CRC is employed in
8 addition to or instead of the check sum.

9 Each pair of data words is interleaved, starting with the Barker code and
10 the first data word. The transmitted bit order for two sequential words, A and
11 B, is D7A, D7B, D6A, D6B, D5A, D5B, D4A, D4B, D3A, D3B, D2A, D2B,
12 D1A, D1B, D0A, D0B, P4A, P4B, P3A, P3B, P2A, P2B, P1A, P1B, POA, POB.

13 D7A is the first transmitted bit. In the illustrated embodiment, DPSK is
14 applied to the interleaved data.

15 In one embodiment (see Fig. 7), the interrogator 50 includes enhanced
16 parallel port (EPP) circuitry 70, DPSK (differential phase shift keyed) circuitry 72,
17 and RF (radio frequency) circuitry 74, as well as a power supply (not shown) and
18 a housing or chassis (not shown). In the illustrated embodiment, the enhanced
19 parallel port circuitry 70, the DPSK circuitry 72, and the RF circuitry 74
20 respectively define circuit card assemblies (CCAs). The interrogator uses an
21 IEEE-1284 compatible port in EPP mode to communicate with the controller 54.
22 The EPP circuitry 70 provides all the digital logic required to coordinate sending
23 and receiving a message to and from a circuit 34. The EPP circuitry 70 buffers

1 data to transmit from the controller 54, converts the data to serial data, and
2 encodes it. The EPP circuitry 70 then waits for data from the circuit 34, converts
3 it to parallel data, and transfers it to the controller 54. In one embodiment,
4 messages include up to 64 bytes of data.

5 The EPP mode interface provides an asynchronous, interlocked, byte wide,
6 bi-directional channel controlled by the controller 54. The EPP mode allows the
7 controller 54 to transfer, at high speed, a data byte to/from the interrogator within
8 a single host computer CPU I/O cycle (typically 0.5 microseconds per byte).

9 The DPSK circuitry 72 (see Fig. 8) receives signals I and Q from the RF
10 circuitry 74 (described below), which signals contain the DPSK modulated
11 sub-carrier. The DPSK circuitry 72 includes anti-aliasing filters 76 and 78
12 filtering the I and Q signals, respectively, and analog to digital (A/D) converters
13 80 and 82 respectively coupled to the filters 76 and 78 and respectively
14 converting the filtered signals from analog to digital signals. The DPSK circuitry
15 72 further includes a combiner 84, coupled to the A/D converters 80 and 82,
16 combining the digital signals. The DPSK circuitry 72 further includes a FIR
17 matched filter 86, coupled to the combiner 84, which filters the combined signals.
18 The DPSK circuitry 72 further includes delay circuitry 88 and multiplier circuitry
19 90 coupled to the FIR matched filter 86 for delaying the signal and multiplying
20 the signal with the delayed signal to remove the sub-carrier. The DPSK circuitry
21 72 further includes low pass filter circuitry 92, coupled to the multiplier 90,
22 filtering the output of the multiplier 90 to remove the X2 component. The DPSK
23 circuitry 72 further includes a bit synchronizer 94 coupled to the filter 92 for

1 regeneration of the data clock. The DPSK circuitry 72 further includes lock
2 detect circuitry 96 coupled to the low pass filter 92 and generating a lock detect
3 signal. The data, clock, and lock detect signal are sent to the EPP circuitry 70.

4 The RF circuitry 74 (see Fig. 9) interfaces with the transmit and receive
5 antennas X1, X2, X3, etc., and R1, R2, R3, etc defining antennas 52. The RF
6 circuitry modulates the data for transmission to a circuit 34, provides a continuous
7 wave (CW) carrier for backscatter communications with a circuit 34 (if backscatter
8 communications are employed), and receives and downconverts the signal received
9 from the transponder unit (which is a backscatter signal in one embodiment).

10 The RF circuitry 74 also includes a power divider 98, and a frequency
11 synthesizer 100 coupled to the power divider 98. The frequency synthesizer 100
12 tunes the RF continuous waver carrier for frequency hopping and band selection.
13 The RF circuitry defines a transmitter, and receives data from the EPP
14 circuitry 70. The RF circuitry 74 includes an amplitude modulation (AM) switch
15 102 that receives the data from the EPP circuitry 70 and amplitude modulates the
16 data onto a carrier. More particularly, the AM switch 102 turns the RF on and
17 off (ON OFF KEY). The RF circuitry 74 further includes a power amplifier 104,
18 coupled to the AM switch 102, to amplify the signal. The RF circuitry 74
19 further includes a switch 106, coupled to the power amplifier 104, for
20 transmission of the amplified signal through a selected one of the transmit
21 antennas X1, X2, X3, etc.

22 During continuous wave (CW) transmission for the backscatter mode, the
23 AM switch 102 is left in a closed position. When the interrogator 50 is

1 transmitting in the CW mode, the circuit 34 backscatters the signal with a DPSK
2 modulated sub carrier. This signal is received via one of the receive antennas R1,
3 R2, R3, etc.. More particularly, the RF circuitry 74 further includes a switch 108
4 coupled to the receive antennas R1, R2, R3, etc. In another alternative
5 embodiment, such as when backscatter communications are not employed, the RF
6 circuitry uses common antennas for both transmission and reception, and alternates
7 use of antennas from multiple available send/receive antennas. The RF circuitry
8 74 further includes a low noise amplifier (LNA) 110 coupled to the switch 108
9 and amplifying the received signal. The RF circuitry 74 further includes a
10 quadrature downconverter 112, coupled to the LNA 110, coherently
11 downconverting the received signal. The RF circuitry 74 further includes
12 automatic gain controls (AGCs) 114 and 116 coupled to the quadrature down
13 converter 112. The amplitude of the signals are set using the automatic gain
14 controls 114 and 116 to provide the signals I and Q. The I and Q signals, which
15 contain the DPSK modulated sub-carrier, are passed on to the DPSK circuitry 72
16 (Fig. 8) for demodulation.

17 Although one interrogator 50 has been described, it may be desirable to
18 provide multiple interrogators depending on the size and layout of a facility, in
19 which case the multiple interrogators will preferably share information.

20 The interrogator or interrogators 50 are respectively selectively connected
21 to the antennas 52 of an array of antennas distributed in at least the passenger
22 areas of the facility, such as in the main terminal 14, the baggage check in area
23 16, the terminal concourse area 18, and the security check area 20. An

1 interrogator connected to any of the antennas 52 has a range covering less than
2 the area of the entire facility 10. More particularly, the more antennas 52 that
3 are provided, the more precisely the location of an individual can be determined
4 (the transmission and reception range of the interrogator can be decreased
5 appropriately). Preferably, some antennas 52 are located in non-passenger areas,
6 such as outdoor areas, to assist in locating individuals or equipment instead of
7 passengers. The antennas 52 are designed for transmission and reception at
8 microwave frequencies (e.g., 2.44 GHz). As described above, the antennas 52 can
9 either comprise combined send/receive antennas, or separate antennas for sending
10 (transmitting) and receiving. If separate antennas are used for sending and
11 receiving, they will be referred to as a single antenna for purposes of the
12 following discussion and claims.

13 Preferably, the antennas 52 are distributed fairly evenly throughout
14 monitored areas of the facility 10. In one embodiment, an area of communication
15 is defined by the interrogator 50 connected to an antenna 52, and the area of
16 communication of the interrogator using one of the antennas 52 overlaps with the
17 area of communication of the interrogator using another one of the antennas 52
18 so that there are no gaps in the areas of the facility desired to be covered by the
19 system.

20 In operation, the interrogator 52 repeatedly transmits a wireless command
21 to the portable wireless transponder device using alternating ones of the
22 antennas 52. In one embodiment, the interrogator is sequentially connected to
23 respective antennas 52, and makes at least one communication attempt using each

1 antenna 52. The device 32 of an individual transmits data identifying the device
2 32 (and thus the bearer or possessor of the device 32) in response to an
3 interrogator command if the device 32 is within communications range of the
4 antenna 52 sending the command. Thus, the individual is located by determining
5 with which antenna the interrogator 50 was able to establish communications with
6 the portable wireless transponder device.

7 Figs. 12 and 13 illustrate routines executed by the controller 54 to locate
8 individuals or equipment in the facility 10.

9 The routine of Fig. 12 is continuously run (during hours of operation of
10 the facility) and includes a step 118 of causing the interrogator to send an
11 "identify" command, which requests that all devices 32 (within communication
12 range) reply with their respective identification numbers. After performing step
13 118, the controller 54 proceeds to step 120.

14 In step 120, the controller 54 deletes old entries and logs identification
15 numbers of devices 32 within the range of the antenna 52 being used. After
16 performing step 120, the controller 54 proceeds to step 122.

17 In step 122, the controller switches the antenna 52 (or antenna pair) being
18 used by the interrogator. After performing step 122, the controller 54 proceeds
19 to step 118.

20 The routine of Fig. 13 is run when it is desired to locate a specific
21 individual or item of equipment (by inputting an identification number of a
22 device 32).
23

1 The routine of Fig. 13 includes a step 124 of receiving (inputting) an
2 inquiry as to the location of a particular individual. After performing step 124,
3 the controller 54 proceeds to step 126.

4 In step 126, the controller determines if the individual has boarded a carrier
5 by checking the logs for antennas at controlled access points (e.g., the gate for
6 the flight the individual was scheduled to take). After performing step 126, the
7 system proceeds to step 128.

8 In step 128, a determination is made as to whether the individual has
9 boarded a carrier. If so, the controller proceeds to step 130. If not, the
10 controller proceeds to step 132.

11 In step 130, the location of the individual is displayed as being on board
12 the carrier (e.g. the airplane). After performing step 130, execution terminates.

13 In steps 132 and 134 (which can be combined), current (most recent) logs
14 are read for all other antennas, and the controller searches to the particular
15 individual in these logs. After performing steps 132 and 134, the controller
16 proceeds to step 136.

17 In step 136, a determination is made as to whether the particular individual
18 was located in any of these logs. If so, the controller proceeds to step 140. If
19 not, the controller proceeds to step 138.

20 In step 138, the controller causes a display to be generated that the search
21 failed or the individual was not located on the premises. After performing step
22 138, execution terminates.
23

1 In step 140, a determination is made as to whether the individual was
2 located in more than one log (in logs associated with more than one antenna).
3 If so, the controller proceeds to step 142. If not, the controller proceeds to step
4 144.

5 In step 142, the location is displayed of the antenna where the logged
6 communication with the particular individual took place. This is presumably
7 where the individual is presently located. After performing step 142, execution
8 terminates.

9 In step 144, because the individual has been logged in more than one
10 antenna location, either both antenna locations can be displayed or, in the
11 illustrated embodiment, signal strength and/or telemetry are used to locate the
12 particular individual's location (and, optionally, direction of travel). After
13 performing step 144, the controller proceeds to step 146.

14 In step 146 the controller causes the location of the particular individual
15 to be displayed. After performing step 146, the controller proceeds to step 148.

16 This system and routine can also be used to track the location of
17 equipment bearing the circuit 34.

18 In one embodiment of the invention, the system 12 further comprises a
19 carrier (e.g., airline) reservation and baggage tracking system 152 (Fig. 2). Any
20 presently used reservation system can be employed. For example, a system such
21 as the systems described in incorporated patents 5,401,944; 5,151,692; 5,051,565;
22 5,010,240; 4,984,156; 4,931,932; 4,449,186; 4,247,795; and 3,750,103 can be
23 employed for the carrier reservation and baggage tracking system 152. The

1 reservation and baggage tracking system 152 includes a computer having a
2 database storing information identifying passengers who have purchased tickets for
3 passage (e.g., a flight), information about scheduled departures (e.g., for flights),
4 information identifying passengers who have checked in (e.g., for a flight), etc.
5 The system 12 further includes a network 154 connecting the interrogator 50 to
6 the carrier reservation and baggage tracking system 152. Any appropriate network,
7 such as a local area network, wide area network, Intranet network, Internet
8 network, etc. can be employed. If multiple airlines or carriers in the facility have
9 separate reservation systems, the network 154 preferably connects all participating
10 reservation systems to the interrogator 50.

11 In this embodiment, the card 32 is used to automatically check in a
12 passenger who enters the facility or a designated area of the facility (e.g., a gate
13 area), as desired.

14 More particularly, the interrogator 50 defines a wireless transponder in
15 communication with the computer of the carrier reservation and baggage tracking
16 system 152. The interrogator periodically sends wireless commands requesting
17 responses from portable identification devices (e.g., the cards 32). The cards 32
18 transmitting identifying data (e.g., a serial number that is associated with the
19 bearer, a Social Security Number, a frequent flyer number, a confirmation number,
20 etc.) in response to receiving a command from the interrogator. The interrogator
21 has a desired coverage area (e.g., in the airport, or in the gate area), and
22 communicates only with cards 32 within the desired area. The computer of the
23 carrier reservation and baggage tracking system 152 modifies the reservation

1 database to indicate that a passenger has checked in, in response to the
2 interrogator 50 receiving a response from a card 32 in the desired coverage area.
3 Thus, the card 32 acts as an electronic boarding pass, saving the passenger from
4 having to stand in line to check in, and reducing labor required by the carrier.

5 Conditions can be imposed before the electronic boarding pass is accepted.
6 For example, in one embodiment, the electronic boarding pass (card 32) is
7 accepted to check in a passenger only within a predetermined time period before
8 a scheduled departure. Thus, if a passenger is in the airport the day before a
9 flight (e.g., to greet an arriving passenger, or for an unrelated flight), the
10 passenger is not considered to be checked in. In one embodiment, the electronic
11 boarding pass is only accepted if the response from the card 32 includes
12 identifying data for a passenger for whom the database in the carrier reservation
13 and baggage tracking system 152 indicates that a ticket for a flight has been
14 purchased. A routine for execution by the system 152 to this effect is provided
15 in Fig. 14, and includes a first step 156 in which the system 152 retrieves a list
16 of passengers having reservations for flights scheduled to leave in the next
17 predetermined time period (e.g., flights scheduled to leave in the next two hours,
18 or next one hour). After performing step 156, the system proceeds to step 158.

19 In step 158, a determination is made as to whether identification data (e.g.,
20 Social Security Number, frequent flier number, serial number, etc.) logged using
21 designated antennas 52 (e.g., in the airport, or in the gate area for the particular
22 flight, etc.) match the identification data of any passengers on the reservation list
23

1 for flights scheduled to leave in the next predetermined time period. If so, the
2 system proceeds to step 160. If not, the system proceeds to step 162.

3 In step 160, the system checks in the qualifying passengers (those logged
4 using designated antennas and matching the identification data of passengers on
5 the reservation list for flights scheduled to leave in the next predetermined time
6 period). The system further assigns seats (this may be based on known customer
7 preferences, such as preferences stored for frequent fliers), and moves the checked
8 in passengers from the reservation list to the checked in list. This is so that
9 there is no need to search for passengers who have already checked in, next time
10 step 156 is executed. After performing step 160, the system proceeds to step
11 166.

12 In step 162, a time delay is imposed so that the system is freed up to
13 perform other tasks. After performing step 162, the system proceeds to step 164.

14 In step 164, the time is updated. In other words, the system time is
15 retrieved for purposes of defining the predetermined time period of step 156.
16 After performing step 164, the system proceeds to step 156.

17 In step 166, a time delay is imposed so that the system is freed up to
18 perform other tasks. After performing step 166, the system proceeds to step 168.

19 In step 168, the time is updated. In other words, the system time is
20 retrieved for purposes of defining the predetermined time period of step 156.
21 After performing step 168, the system proceeds to step 156.

22 In one embodiment, the transponder device 32 is manufactured using
23 techniques such as those described in a commonly assigned U.S. patent application

1 (attorney docket MI40-048) titled "Tamper Resistant Smart Card and Method of
2 Protecting Data In a Smart Card", filed February 13, 1997, listing as inventor
3 John R. Tuttle et al., and incorporated herein by reference. In one embodiment,
4 the device 32 includes a magnetic stripe which the carrier (e.g., airline) can use
5 for various purposes instead of or in addition to using the antennas 42. For
6 example, an airline may use the antennas 42 to check in a passenger, but may use
7 the magnetic stripe with a card reader at a gate 22 (such as the card reader
8 described in U.S. Patent No. 5,010,240) in place of a boarding card when a
9 passenger passes through the gate 22 to board a plane, or vice versa.

10 In one embodiment of the invention (see Figs. 1-3), the system 12
11 communicates custom travel (e.g. flight) information to a passenger. The system
12 12 uses the computer of the previously described carrier reservation and baggage
13 tracking system 152. The system further includes monitors 170 and/or speakers
14 172, and appropriate converters 174 and 176 connecting the monitors and speakers
15 to the network. The converters 174, for example, may convert from EGA, VGA,
16 or super VGA to a standard television signal, and the converters 176, for example,
17 may be sound cards or equivalent circuitry. Whenever a passenger is in proximity
18 to an antenna located near a monitor or speaker, the interrogator 50 determines
19 this in the same way that the interrogator 50 locates passengers, by
20 communicating with a card 32 possessed by the passenger. The system accesses
21 the reservation and baggage tracking system 152, retrieves the departure
22 information for that passenger, and displays the information on the monitor as
23 shown in Fig. 3. More particularly, the system uses the existing reservation

1 database of the system 152, including information identifying passengers who have
2 purchased tickets for a flight, and information about scheduled departures. The
3 information includes existing information such as a flight, bus or train number
4 178, destination 180, a gate, bay, or track number 182, scheduled departure time
5 184, and status information 186 (e.g., boarding, on time, delayed, gate change, see
6 agent, cancelled, etc.).

7 If multiple passengers are in communications range of the antenna near the
8 monitor 170, information will appear tailored for each of these passengers, as
9 shown in Fig. 3. The information displayed therefore preferably includes the
10 passenger's name 188, as well. The information may be sorted (arranged) by
11 passenger name in alphabetical order, by scheduled departure time, or by order of
12 detection of the passengers by the interrogator 50.

13 In one embodiment, shown in Figs. 10 and 11, an alternative card 32B is
14 provided which is similar to the card 32, but further includes a display 190
15 coupled to the integrated circuit 34. The display 190 can be a liquid crystal
16 display, LED display, or other type of display. In this embodiment, the
17 customized information for the passenger bearing the card 32B appears on the
18 display 190. The display 190 can be activated by bringing the card 32B in
19 communication range with a designated antenna 52 in the facility (which may be
20 arranged to have a small range requiring close proximity, so the display is not
21 continuously activated while the passenger travels through the facility).
22 Alternatively, the card 32B is further include an actuator 192 coupled to the
23 integrated circuit 34, actuation of which causes display of the information. The

1 information can be similar to the information displayed on the monitor 170, if a
2 monitor 170 is used, except that the name of the passenger may be omitted
3 because the bearer of the card 32B is obviously the passenger. On the other
4 hand, it may be desirable to display the passenger name to avoid mistaken
5 swapping of the cards 32B or to avoid theft. The actuator 192 may be connected
6 to an analog or digital input pin of the integrated circuit.

7 In the embodiment of Figs. 10 and 11, the card further includes a buffer
8 memory 194 coupled to a serial input/output port of the integrated circuit 34, a
9 controller 196, and a display driver 198. The serial input output port is used to
10 load the buffer memory 194, and then the controller 196 and display driver 198
11 drive the display 190.

12 Although the system of the invention has been described in connection with
13 an airport and airline reservation system, it will be apparent that the system also
14 has application to other travel depots and reservation systems, for those travelling
15 by train, boat, bus, etc.

16 Various other applications for the system 10 will readily be apparent to
17 those of ordinary skill in the art.

18 In compliance with the statute, the invention has been described in language
19 more or less specific as to structural and methodical features. It is to be
20 understood, however, that the invention is not limited to the specific features
21 shown and described, since the means herein disclosed comprise preferred forms
22 of putting the invention into effect. The invention is, therefore, claimed in any
23

1 of its forms or modifications within the proper scope of the appended claims
2 appropriately interpreted in accordance with the doctrine of equivalents.
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